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(19) (CA) # CANADIAN PATENT

(54) HOT WATER EXTRACTION AND HYDROCYCLONE TREATMENT OF TAR SANDS

Treats tails & middlings in cyclone

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ABSTRACT OF THE INVENTION

An improved process for recovering bitumen from tar sands utilizing hot water extraction techniques which comprises settling a tar sand-water mixture in a separation zone to provide an upper froth layer, a sand tailings layer and a middlings layer, recovering the upper froth and thereafter subjecting the middlings layer and the sand tailings layer of the separation zone to centrifugal force in a hydrocyclone which provides additional enriched bitumen streams which can be subsequently treated in an air scavenger zone to provide additional froth product.

BACKGROUND OF THE INVENTION

The present invention relates to an improved hot water process for the extraction of bitumen from tar sands. Specifically, the present invention provides a process for improving the recovery of bitumen from middlings and tailings streams associated with the gravity settling procedure of the hot water extraction method for the recovery of bitumen from tar sands.

Tar sands which are also known as oil sands and bituminous sands are siliceous materials which are impregnated with a heavy petroleum. The largest and most important deposits of the sands are the Athabasca sands, found in northern Alberta, Canada. These sands underlay more than 13,000 square miles at a depth of 0 to 2000 feet. Total recoverable reserves after extraction and processing are estimated at more than 300 billion barrels--just equal to the world-wide reserves of conventional oil, sixty percent of which is in the Middle East. By way of contrast, the American Petroleum Institute estimated total United States oil reserves at the end of 1965 at 39.4 billion barrels.

The tar sands are primarily silica, having closely associated therewith an oil film which varies from about 5 percent to 21 percent by weight, with a typical content of 13 weight percent of the sand. The oil is quite viscous--6° to 8° API gravity--and contains tppically 4.5 percent sulfur and 38 percent aromatics.

The sands contain, in addition to the oil and sand components, clay and silt in quantities of from 1 to 50 weight percent, more usually 10 to 30 percent. The sands also contain a small amount of water, in quantities of 1 to 10 percent by weight, in the form of a film around the sand grains.

Several basic extraction methods have been known for many years for the separation of oil from the sands. In the so called "cold water" method, the separation is accomplished by mixing the sands with a solvent capable of dissolving the bitumen constituent. The mixture is then introduced into a large volume of water, water with a surface agent added or a solution of a neutral salt in water, which salt is capable of acting as an electrolyte. The combined mass is then subjected to a pressure of gravity separation.

In the hot water method, as disclosed in Canadian Patent 841,581 issued May 12, 1970, the bituminous sands are jetted with steam and mulled with a minor amount of hot water at temperatures of 170°F. to 190°F., and the resulting pulp is then dropped into a turbulent stream of circulating hot water and carried to a separation cell maintained at a temperature of about 185°F. In the separation cell, sand settles to the bottom as tailings and oil rises to the top in the form of a froth. An aqueous middlings layer comprising clay and silt and some oil is found between these layers. This basic process may be combined with a scavenger step for further treatment of the middlings layer obtained from the primary separation step to recover additional amount of oil therefrom.

The middlings layer either as it is recovered from the primary process or as it is recovered after the scavenger step comprises water, clay and oil. The oil content is, of course, higher in middlings which have not undergone secondary scavenger steps.

A method for recovering bitumen from tar sands comprising the use of hydrocyclones is disclosed in U. S. Patent 2,910,424 issued October 27, 1959 to M. R. Tek et al.

This disclosure provides a method by which bitumen is separated from tar sands in a hydrocyclone and thereafter filtered and deemulsified to provide a mineral-free bitumen product. Although the use of hydrocyclones to recover bitumen from tar sands is provided, this method of itself is found to be economically inefficient in the filtering and deemulsifying steps and therefore commercially unattractive.

Now an improved process utilizing hot water extraction techniques and hydrocyclones has been developed which efficiently and economically provides for the recovery of bitumen from tar sands. Specifically, a method has been developed whereby the use of hydrocyclones as a part of a hot water extraction process for the recovery of bitumen from tar sands provides a new and improved method whereby bitumen is recovered from tar sands in an efficient and economically effective manner.

DESCRIPTION OF THE INVENTION

The present invention provides an improvement in the hot water method of extracting bitumen from tar sands. Specifically, the present method utilizes hydrocyclones to treat the sand tailings layer and middlings material recovered from a settling vessel. Additional bitumen is recovered from these streams by use of hydrocyclones. The additional bitumen is thereafter aerated in a scavenger zone to provide additional froth product to thereby substantially enhance the recovery of bitumen from tar sands. Thus the present invention is an improved hot water extraction process for recovering bitumen from tar sands. In essence the invention comprises an improvement over the presently known hot water process whereby bitumen which is lost in the sand tailings layer and

the middlings layer from the hot water settling vessel is recovered to provide a substantially improved hot water process for the extraction of bitumen from tar sands.

The hot water process which the current invention provides an improvement over is disclosed in Canadian Patent 841,581 issued May 12, 1970 to Floyd et al. Essentially, the hot water extraction process as disclosed in the Floyd et al. patent provides a reasonably efficient means of recovering bitumen from tar sands. However, even this procedure is open to improvement. Specifically, the present method provides a means whereby the larger mineral particles are removed from the sand tailings layer and the middlings material recovered from a hot water gravity settling zone to provide additional bitumen-rich feed to the scavenger zone and thereby improve the quantitative recovery of bitumen from tar sands. In essence by removing the larger mineral particles from the middlings material and the sand tailings layer, an improved bitumen-rich feed is provided to the scavenger step of the hot water extraction process. In particular, the bitumen normally lost when the sand tailings layer is discarded is recovered.

The type of hydrocyclone suitable for use in the process of the present invention is well known in the art. Generally, a suitable hydrocyclone can be defined as a hollow closed vessel having a cylindrical base closed at one end with the other end attached to the larger open end of an inverted frusto cone. The cyclone has a feed inlet to its inner chamber at its cylindrical base and an inlet for additional water in its conical section. The cyclone also has a bitumen-rich stream outlet in its base section and a mineral

outlet at the apex of the frusto cone section. Within the cylindrical base a vortex finder is usually provided.

When the cyclone is employed, the vortex formed within the cyclone provides an overflow of a bitumen-enriched stream which is recovered from the overflow outlet in the base section of the cyclone. Water is also fed tangentially into the cyclone through feed inlets on the conical section thereof, the tangent of this inlet being directionally identical to the base inlet tangent. The additional water washes the coarse minerals and aids in the flow of the internal vortex within the cyclone to improve recovery of bitumen. The sand separated from the bitumen within the cyclone is withdrawn from the apex of the cyclone and discarded.

So that the process of the present invention can be more clearly understood, the figure in the drawing is herewith provided. Referring to the drawing, tar sands are fed into the process through line 1 to conditioning drum 5. Water is fed into conditioning drum via line 2. Also, recycled water from separation cell 15 can be transferred into the conditioning drum via line 3. As a general rule, the total quantity of water provided in the conditioning vessel is in the form of liquid water and is generally in the range of 0.2 to 3.0 tons per ton of tar sands. The water provided to the conditioning vessel can also be in the form of steam. The steam introduced into the vessel is of a sufficient quantity to raise the temperature in the conditioning drum to the range of 130°F. to 210°F. and preferably to above 170°F.

The tar sand-water mixture is mulled within the conditioning vessel and thereafter passes out of the vessel as indicated by line 4 through screen 7. The purpose of screen 7 is to remove from the tar sands pulp any debris, rocks or oversized lumps as indicated at 6. These tar sands pass from screen 7 to sump 10 wherein additional water is added via line 9 or through line 11 which provides recycled middlings from separation cell 15 as hereinafter defined. The diluted tar sands pulp is thereafter transferred from sump 10 into separation cell 15 via line 13. Separation cell 15 is comprised of a large cylindrical or rectangular tank or a battery of tanks which if desired can be provided with heating coils to maintain temperatures in the range of 130°F. to 210°F. and preferably above 150°F. The diluted tar sands pulp from the sump is settled in vessel 15 to provide an upper bitumen froth substantially reduced in mineral matter, a middlings material containing mineral matter, water and bitumen and a tailings layer substantially comprised of water, mineral and some bitumen. The tailings layer is removed from the separation zone via line 16 and is transferred to hydrocyclone 18. First middlings stream is withdrawn via line 23 from separation cell 15 and is transferred to hydrocyclone 24. A second middlings material stream can be withdrawn from separation cell 15 via line 12 if desired and transferred via line 11 into sump 10 for dilution of the tar sands pulp therein or into line 3 for dilution of the tar sands feed in the conditioning vessel.

The middlings material and sand tailings from the settling zone each separately enter cyclones 24 and 18, respectively, tangentially at a pressure sufficient to create centrifugal force greater than that of gravity and thereby

promote the formation of a vortex within the center of each of the cyclones. The vortex within the cyclone results in the separation of the less dense bitumen and fine mineral from the coarse mineral particles. Fresh water is also added to cyclone 18 in the conical portion of the cyclone via line 17 and to cyclone 24 in the conical portion thereof via line 28.

The addition of the fresh water to the conical section of the cyclone substantially improves the efficiency of bitumen recovery within the cyclone from the bitumen-mineral-water mixture. Sand separated from the bitumen is withdrawn from the cyclone 18 via line 19 from the apex thereof and transferred into line 20 from which it is discarded. The bitumen-rich stream recovered from cyclone 18 also containing clay and water is transferred into scavenger zone 27 via line 22 through line 21.

Sand separated from bitumen in hydrocyclone 24 is withdrawn via the apex outlet and transferred via line 26 into line 20 from which it is discarded. The bitumen-rich stream recovered from cyclone 24 is transferred via line 25 into line 22 where it is combined with the bitumen-rich stream from cyclone 18. Tailings from settler vessel 31 as hereinafter defined can also be added to the combined bitumen-rich streams recovered from the hydrocyclones in line 22. The tailings from settler 31 can be transferred via line 32 into line 22. The combined feeds are thereafter transferred into scavenger zone 27.

In scavenger zone 27, air is added via line 35 to aid in the separation of bitumen from the mineral matter in the feed to provide an upper froth layer and a lower layer

of water and clay substantially depleted of bitumen which is withdrawn via line 29 and discarded through line 20. The upper froth layer of scavenger 27 comprised substantially of bitumen and water is withdrawn via line 30 and transferred to settling vessel 31. The upper froth layer of settling vessel 31 can thereafter be combined in line 34 via line 33 with froth from line 14. The upper froth layer of settling zone 15 is withdrawn via line 14. The combined froth from lines 14 and 33 is recovered as the bitumen froth product of the process. The tailings from settler 31 can be transferred to line 22 via line 32 or can be discarded.

The effectiveness of the hydrocyclone can be more easily understood by referring to the drawing in Figure II. In the figure hydrocyclone 40 is comprised of a hollow cylindrical base 42 closed at one end and connected at the other end to the wider end of a hollow inverted frusto cone 41. The cylindrical base has a feed inlet means 43 and froth overflow outlet means 44. Disposed within the cavity of base 42 is vortex finder 45 which is a hollow cylinder open at both ends, concentrically disposed within the base and fixed to the internal walls of the base by supports 46 which divide the base cavity into upper bitumen stream overflow section 48 and lower inlet section 52. The lower section 52 forms a part of the larger internal cavity of the cyclone as indicated by 47.

The conical section is an inverted frusto cone with its larger opening complimentary to and fixed to the open end of base 42. Midway between the base and apex of the conical section are inlet means 50 which communicate

tangentially with the internal cavity 47 of the cyclone to provide a means by which additional water is added to the cyclone. An underflow outlet is provided at the apex of cyclone 40 at 49 whereby the underflow is transferred from the cyclone.

As disclosed herein and illustrated in the figures, the hydrocyclone is shown in a vertical position with its base uppermost and the apex of the cyclone at the bottom thereof. This presentation is made to illustrate the preferred embodiment of the apparatus whereby the advantages of gravitational forces can be utilized to the utmost. However, the hydrocyclone or hydrocyclones utilized in the instant invention can be disposed in horizontal or any other position other than that shown and still provide the necessary function in the process of this invention. Also, the cyclone as represented can be a bank of two or more cyclones. As hereinafter disclosed, all percentages are by weight unless otherwise defined.

As an example of the operation of the hydrocyclone in the method of this invention and again referring to the drawing in Figure I, a middlings comprising 82 percent water, 15 percent mineral matter and the remainder bitumen at a temperature of approximately 185°F. is transferred from line 23 into inlet means 43 of cyclone 40 as shown in Figure II. The middlings material is fed tangentially into the cyclone at the rate of 1500 gallons per minute, the coarse mineral matter of the feed as a result of the centrifugal force imposed moves into the outer fluid stream downwardly within the cyclone while an internal vortex is concurrently formed in which the bitumen and fine mineral matter moves upwardly through vortex

finder 45 into the bitumen stream overflow cavity 48 and thereafter exiting the cyclone into overflow line 24 through exit 44. The bitumen-rich stream is recovered at about 1100 gallons per minute. Concurrently, additional water at the rate of 400 gallons per minute is added to the cyclone through feed inlets 50 located on the conical part of the cyclone, the water being supplied via lines 28. The additional water supplied to the cyclone in the conical section aids in the separation of the bitumen emulsions from coarse sand particles to essentially provide that coarse particles of mineral matter which are withdrawn from the cyclone through apex outlet 49 and transferred therefrom at the rate of about 800 gallons per minute through line 26 are substantially free of bitumen.

By the addition of a hydrocyclone to process middlings from the hot water gravity settler at this point in the hot water extraction method, a substantial quantity of coarse mineral matter which would otherwise enter the scavenger zone is removed to thereby provide a middlings feed material having a higher bitumen concentration to the scavenger zone thereby resulting in a substantially improved bitumen recovery process. As a further advantage of this process, less bitumen is withdrawn with coarse sand tailings from the scavenger zone thereby effecting an improvement in the total quantitative recovery of bitumen from the original tar sands processed.

Again referring to the drawing in Figures I and II, a tar sands tailings comprising 44.2 percent water, 55 percent mineral matter and 0.8 percent bitumen is transferred from line 16 through inlet means 43 into a second cyclone, cyclone 40. Being fed tangentially into the cyclone at 1500 gallons per minute, the coarse mineral matter of the tailings feed as a result of the centrifugal force imposed moves in the outer fluid stream downwardly within the cyclone while an

internal vortex is concurrently formed in which the bitumen and fine minerals move upwardly through vortex finder 45 into bitumen stream overflow cavity 48 and thereafter exiting the cyclone into overflow line 21 through exit 44. The bitumen-rich stream is recovered at about 1100 gallons per minute and contains 1.2 percent bitumen, 23.3 percent mineral matter and 75.5 percent water. Concurrently, additional water at the rate of 400 gallons per minute is added to the cyclone through feed inlets 50 located in the conical part of the cyclone, the water being supplied via lines 17. The additional water supplied to the cyclone in the conical section aids in the separation of the bitumen emulsions from coarse sand particles. Coarse particles of mineral matter reduced in bitumen content are withdrawn from the cyclone through apex outlet 49. The apex discharge is transferred therefrom at the rate of about 800 gallons per minute through line 19 and is comprised of 0.3 percent bitumen, 70.0 percent mineral matter and 29.7 percent water.

The bitumen-rich streams recovered from the hydrocyclones are combined in line 22 and transferred into scavenger zone 27 as shown in Figure I. In scavenger zone 27, the froth is aerated and thereby separates into a mineral tailings lower layer and an upper oil froth layer.

The aerated froth floats to the top of scavenger zone 27 and is transferred therefrom via line 30 into settler zone 31 or directly to froth recovery line 34. The froth can be settled in zone 31 to provide an upper bitumen froth and a lower mineral-water tailings. The mineral-water tailings can be recycled to scavenger zone 27 via lines 32 and 22. The upper froth in settler zone 30 is transferred via line 33 into line 34 and therein combined with froth from settler

15 for further processing not shown. Tailings from scavenger zone 27 which are substantially depleted of oil can be withdrawn via line 29 and discarded through line 20.

Thus by the method of the present invention mineral-rich streams discharged from the gravity settler of the hot water extraction process for the recovery of bitumen from tar sands are subject to a hydrocyclone separation step by which an additional stream containing bitumen is sent to a scavenger step to provide additional bitumen froth product. Therefore, the method of the present invention provides a process for the recovery of bitumen from tar sands which comprises the steps of:

(a) forming a mixture of tar sands and water;

(b) passing the mixture into a separation zone;

(c) settling the mixture in a separation zone to form an upper bitumen froth layer, a middlings layer comprising water, clay and bitumen and a sand tailings layer and

(d) recovering the upper bitumen froth layer, the improvement which comprises:

(i) treating a part of the middlings stream from the settler in a hydrocyclone and recovering additional bitumen therefrom;

(ii) treating a part of the sand tailings layer in a hydrocyclone and recovering additional bitumen therefrom;

(iii) subjecting the bitumen recovered from steps (i) and (ii) to an air scavenger treatment in a scavenger zone and

(iv) recovering additional bitumen froth from said scavenger zone.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. In a hot water process for extracting bitumen from tar sands comprising settling the tar sands-water mixture in a separation zone at a temperature in the range of 130°F. to 210°F. to form an upper bitumen froth layer, a sand tailings layer and a middlings layer wherein the froth layer is recovered, the improvement which comprises:

(a) treating at least a part of said sand tailings layer in a hydrocyclone and recovering an enriched bitumen stream therefrom;

(b) treating at least a part of said middlings layer in a hydrocyclone and recovering an additional bitumen enriched stream therefrom and

(c) treating the bitumen enriched streams from steps (a) and (b) in an air scavenger zone to provide additional bitumen froth.

2. A process according to Claim 1 wherein said additional enriched bitumen froth is combined with the froth recovered from said separation zone.

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3. In a hot water process for extracting bitumen from tar sands comprising the steps of:

(a) forming a mixture of tar sands and water;

(b) passing the mixture into a separation zone;

(c) settling the mixture in a separation zone to form an upper bitumen froth layer, a middlings layer and a sand tailings layer and

(d) recovering the upper bitumen froth layer, the improvement which comprises:

(i) transferring at least a part of said middlings stream to a hydrocyclone and recovering additional bitumen therefrom;

(ii) transferring at least a part of said sand tailings layer to a hydrocyclone and recovering additional bitumen therefrom and

(iii) subjecting the bitumen recovered from steps (i) and (ii) to an air scavenger treatment in a scavenger zone to provide additional bitumen froth.

4. A process according to Claim 3 wherein said additional bitumen froth is combined with the froth recovered in step (d).

5. A hot water process for extracting bitumen from tar sands comprising:

(a) forming a mixture of tar sands and water including that of the hereinafter specified recycle stream;

(b) settling the tar sands mixture in a separation zoneat a temperature in the range of 130°F. to 210°F. to form an upper oil froth layer, a middlings layer comprising water, clay and oil and a sand tailings layer;

(c) separately removing the oil froth layer;

(d) removing a first stream of middlings from the

separation zone and utilizing the same as the aforesaid recycle stream in forming said mixture of step (a);

(e) passing a second stream of middlings into a hydrocyclone tangentially at a pressure sufficient to produce centrifugal force in excess of gravity and recovering from said cyclone a stream enriched in bitumen;

(f) passing a stream of tailings into a hydrocyclone tangentially at a pressure sufficient to produce centrifugal force in excess of gravity and recovering from said cyclone a stream enriched in bitumen and

(g) subjecting the bitumen enriched streams of steps (e) and (f) to an air scavenger treatment in a scavenger zone to provide additional bitumen froth.

6. A process according to Claim 5 wherein the froth recovered from the scavenger zone is combined with the froth product of step (c) to provide a bitumen froth product suitable for further processing.

7. A method according to Claim 5 wherein additional water is fed into the hydrocyclone in the same direction as that of the feed material.

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Fig. 1

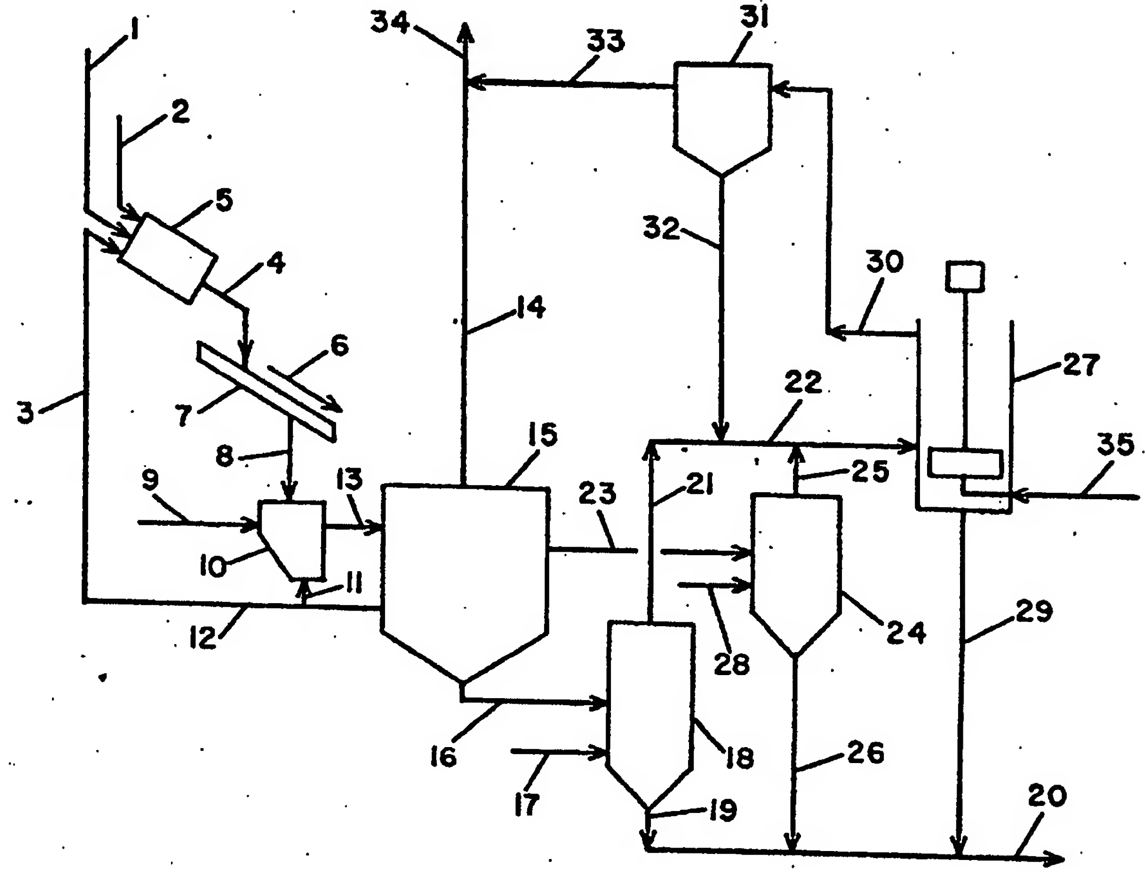
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Fig. 2